

**BLACKSTONE RIVER BASIN
WORCESTER, MASSACHUSETTS**

**QUINSIGAMOND POND DAM
MA 00139**

**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**

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**DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
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AUGUST 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Quinsigamond Pond Dam is an earthfill dam with an arched, stone masonry spillway. The dam and spillway is about 240 feet long and 18 feet high. The dam is considered to be in fair condition. In addition, the dam has been classified in the "high" hazard category. Based on size and hazard classification, the test flood is $\frac{1}{2}$ the PMF.			

QUINSIGAMOND POND DAM

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PHASE I INSPECTION REPORT
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PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00139

Name of Dam: Quinsigamond Pond

Town: Worcester

County and State: Worcester County, Massachusetts

Stream: Middle River, a tributary of the Blackstone
River

Date of Inspection: August 3, 1978

Quinsigamond Pond Dam is an earthfill dam with an arched, stone masonry spillway. The spillway comprises the major portion of the dam. An earlier dam was constructed at the site some time prior to 1833. The present spillway was built in 1891, and there were subsequent modifications to the embankment and outlets. The dam and spillway is about 240 feet long and 18 feet high. The spillway section, which is 155 feet long, has a cut-off wall of 4-inch sheeting that extends at least 10 feet into the embankment. There are two visible outlet gate structures in the south abutment area. One gate is inoperable and the other gate is reportedly still operable, although it has not been used in over 5 years.

Quinsigamond Pond Dam was neither designed nor constructed by current approved, state-of-the-art procedures. Based upon the visual inspection at the site and the limited engineering data available, there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the Quinsigamond Pond Dam is considered to be in fair condition. In addition, the dam has been classified in the "high" hazard category.

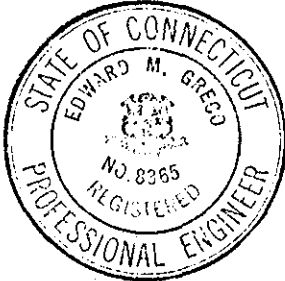
The following visible signs of distress indicate a potential hazard at the dam: heavy siltation upstream of the dam, resulting in the accumulation of weeds, brush and debris that seriously restricts spillway flow and reduces the storage capacity of the pond; the deteriorating condition of the flashboards; the growth of grass between the blocks of the face of the spillway; the missing gate stem at one outlet; trees growing on the embankment, and stonework missing from the north abutment of the spillway.

Hydraulic analyses indicate that the spillway can discharge a flow of 6,600 cfs at El 445.7, which is the low point of the dam. Based on size and hazard classifications in accordance with Corps guidelines, the test flood is one-half the maximum probable flood. The inflow test flood of 17,140 cfs, is adjusted for surcharge storage, resulting in an outflow of 17,075 cfs. This outflow will overtop the main dam by a maximum height of 3.1 feet. The spillway is inadequate since it can discharge only 38 percent of the test flood before the dam is overtopped. However, due to the regulating effect of the upstream flood control structure which was installed in 1959, it is unlikely that overtopping the dam is a serious hazard. However, it is recommended that a definite surveillance plan and warning system be developed for use during periods of unusually heavy rain or runoff, since overtopping could result in complete failure of the dam.

Further investigations to assess the adequacy of the dam are not considered necessary at this time. However, an analysis should be performed to determine the limits of dredging of soil upstream of the dam so that the stability and impermeability of the dam is unimpaired. For the present time, it is recommended that the Owner remove the remaining flashboards from the weir; dredge soil and vegetation from the area upstream of the spillway; repair the outlet works next to the south abutment of the spillway; clear trees and brush from the earth embankment; and replace the blocks missing from the wall at the north abutment. The Owner should also implement a systematic program of inspection and maintenance.

The recommendations and remedial measures described in Section 7 should be implemented by the Owner

within a period of one year after receipt of this Phase I Inspection Report. An alternative to these recommendations would be draining the pond and breaching or removing the dam. However, prior to breaching the dam all accumulated soil within the pond should be removed and disposed of offsite.



A handwritten signature in cursive script, appearing to read "Edward M. Greco".

Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

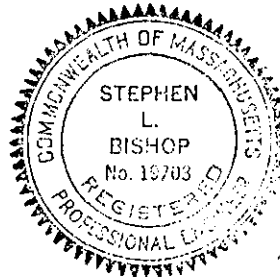
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Approved by:

A handwritten signature in cursive script, appearing to read "Stephen L. Bishop".

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703



This Phase I Inspection Report on Quinsigamond Pond Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials
Branch
Engineering Division

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

SAUL C. COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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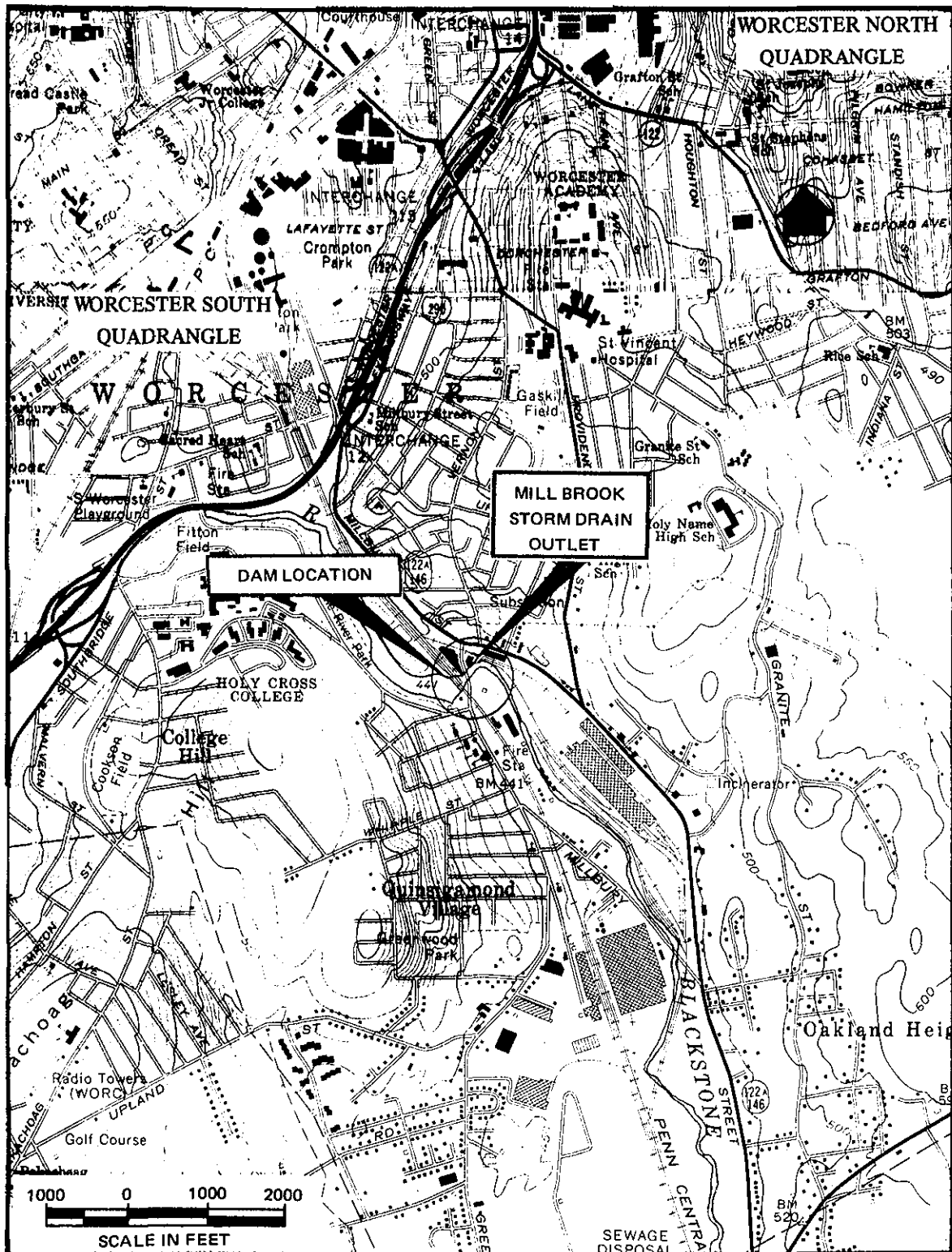
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**OVERVIEW
QUINSIGAMOND POND
WORCESTER, MASSACHUSETTS**



VIEW FROM SOUTH ABUTMENT

**Location and Direction of Photographs
Shown on Figure in Appendix B**



LOCATION MAP - QUINSIGAMOND POND DAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

QUINSIGAMOND POND

SECTION 1

PROJECT INFORMATION

1.1 General

- a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Metcalf & Eddy, Inc. under a letter of May 3, 1978, from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0306 has been assigned by the Corps of Engineers for this work.
- b. Purpose:
 - (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
 - (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
 - (3) Update, verify and complete the National Inventory of Dams.

1.2 Description of Project

- a. Location. The dam is located on Middle River, a tributary of the Blackstone River, in the City of Worcester, Worcester County, Massachusetts (see Location Map, and Watershed Plan, Figure D-1).
- b. Description of Dam and Appurtenances. Quinsigamond Pond Dam consists primarily of an arched, mortared stone masonry spillway with an earthfill embankment at the southern end. The dam and spillway are about 240 feet long and the dam has a maximum height of 18 feet. The spillway is 155 feet long and constructed of mortared stone blocks with a battered downstream face and a stepped upstream face (see Figure B-3). Drawings indicate that there is a cutoff of wood sheeting beneath the spillway wall 3 feet from the upstream face. This sheeting is shown to extend laterally at least 10 feet beyond the ends of the spillway. The crest of the dam is comprised of granite cap blocks 5.4 feet wide, and varies from El 440.8 to 441.2. Flashboards 1.8 feet high are mounted with steel pins on the northern 90 feet of the crest. The flashboards have collapsed along the southern portion of the crest. The top of the flashboards varies from El 442.6 to 443.0. Sidewalls of the spillway are constructed of mortared stone and are 4.7 feet (south end) to 4.9 feet (north end) above the crest. Drawings indicate that the toe of the dam has been protected by a 12-foot-wide apron, constructed of concrete and covered with wood planking. At the downstream edge of this apron is another cutoff of wood sheeting. The spillway discharges into a recessed channel 165 feet wide with vertical, mortared stone walls 12.5 feet high.

The crest of the earth fill embankment at the south end of the spillway is irregularly

shaped and is at an approximate elevation of 445.5. The upstream face of the dam is a vertical, mortared stone wall. The downstream face has been filled in approximately level with the crest to construct a road and railroad tracks. A locked chain-link fence is along the crest and Greenwood Street to prevent access to the outlet structures.

There are two known outlet structures for the dam. One, located at the south abutment of the spillway, is a 6-foot-long, mortared stone sluiceway controlled by a 6-foot by 5-foot slide gate. This gate is operated by a rack and pinion mechanism mounted on grating. The wooden portion of the gate stem is missing and the gate is inoperable. The invert elevation of this outlet is 433.4, and it discharges at the downstream face of the spillway abutment.

A second outlet is located 66 feet south of the spillway, near the abutment of the dam. It is a concrete sluiceway controlled by a 4-foot by 3-foot slide gate. The gate, which is reportedly operable, can be regulated by a rack and pinion mechanism mounted on the headwall of the conduit. The outlet was used to provide water to a U. S. Steel factory. The length and discharge point of this outlet are unknown. There is also evidence of two other abandoned outlets within the pond. There is no information available on these outlets.

- c. Size Classification. Quinsigamond Pond Dam is classified in the "small" category since it has a maximum height of 18 feet and a maximum storage capacity of 180 acre-feet.
- d. Hazard Classification. Downstream of the dam is a heavily industrialized area, including several large factories and bridges for a railroad, Greenwood Street, and Millbury Street. In the event of overtopping and complete failure of the dam, more than a few lives could be lost and extensive property damage could occur. Accordingly the dam has been classified in the "high" hazard category.

- e. Ownership. The dam is located on property owned by Riley Stoker Company, P. O. Box 547, Worcester, Massachusetts 01613. Mr. Tom Kennedy (617-852-7100 ext. 234) granted permission to enter the property and inspect the dam. Prior to February 1973 the dam and water rights were owned by U. S. Steel Corporation.
- f. Operators. There are no known operators of this dam. The outlet structures are inside a 5-foot-high, locked chain-link fence, and the Riley Stoker Company has the key.
- g. Purpose of Dam. Until 1973, the dam provided water for industrial purposes at a steel mill. It used to be called "South Works Pond" and, in 1947, supplied 18.7 million gallons of water per day to the American Steel and Wire Company (see listing of ponds in Figure D-1). The dam has not been used since 1973, and now serves indirectly for flood control.
- h. Design and Construction History. An earlier dam was constructed at the site of the present dam some time prior to 1833. There are no drawings available that show its construction. The existing spillway section of the dam was built about 1891 (see Figure B-3). At that time, the dam was owned by the Washburn & Moen Manufacturing Company. Some time between 1891 and 1947, the dam became the property of American Steel & Wire Company, a subsidiary of U. S. Steel Corporation, which owned the dam until 1973.

Previous inspection reports indicate that the flashboards were in place and the outlet gates were in use as early as 1925.

In 1936, the dam was repaired and the earth embankment and a cut off of wood sheeting were extended 36 feet (see note on inspection listing, page B-4). In 1945, an inspection report stated that a "new concrete headwork" had been constructed for the outlet gate near Greenwood Street.

1. Normal Operating Procedure. There are no operating procedures at the dam. There are two known outlet structures controlled by slide gates located near the south end of the dam. The outlet next to the spillway is missing the wooden portion of the gate stem and is inoperable. The outlet next to Greenwood Street is reported to be operable, but has not been opened in over five years. There is also evidence of two other abandoned outlets within the pond. There is no information available on these outlets.

The spillway for Quinsigamond Pond Dam is ungated. Sections of the existing flashboards have collapsed and a major portion of the pond near the spillway is filled with silt. Normal flows are restricted to about 40 percent of the length of the crest.

1.3 Pertinent Data

- a. Drainage Area. The approximately 40,300 acre (63 square mile) drainage area includes the basins of Ramshorn Brook, Dark Brook, Tatnuck Brook, Kettle Brook, and Middle River. About 25 dams are located upstream of Quinsigamond Pond, and seven of these reservoirs are used for water supply. Runoff from approximately 11.3 square miles of the area directly tributary to Quinsigamond Pond is diverted by the City of Worcester drainage system (Mill Brook Storm Drain) and discharged downstream of the dam into the Blackstone River. This results in a drainage area of 51.7 square miles directly tributary to the pond. A diversion tunnel is also located on Kettle Brook and conducts flood water downstream of Quinsigamond Pond Dam.

The drainage area is about 50 percent rural and 50 percent urban. Rural areas are sparsely populated, generally wooded, and have gentle to steep slopes. Urban areas are moderate to densely populated, with few wooded areas, and have flat to moderate slopes.

Discharge from Quinsigamond Pond Dam is to the Blackstone River, located directly downstream. The downstream area is a heavily developed, industrial and commercial section of Worcester.

- b. Discharge. Normal discharge is over the spillway which is ungated. The spillway weir is about 155 feet long, and the crest elevation varies from 440.8 to 441.2. Wooden flashboards 1.8 feet high are mounted on the northern 90 feet of the crest. Water drops about 8 feet vertically into a downstream channel which is 165 feet wide with vertical stone sidewalls 12.5 feet high. Three granite block piers that support a railroad bridge are located 20 feet downstream of the dam. Two concrete piers that support the Greenwood Street bridge are located 115 feet downstream of the dam. The channel has a downstream slope of less than 1 percent and narrows to 100 feet wide at 500 feet below the dam. At that point, the channel makes a 90 degree turn to the right and continues in a southeasterly direction.

The spillway can discharge an estimated 6,600 cfs at El 445.7 which is the low point of the dam. The inflow test flood, which has been adjusted for water diverted to the Worcester Diversion Tunnel and Mill Brook Storm Drain, is 17,140 cfs and will overtop the dam by a maximum of 3.1 feet.

The maximum flood level at the dam is unknown. County personnel recall that the dam was not overtopped in 1936 or 1955; however, a 1936 flood level of El 447 is shown on the list of inspections (see page B-4). This is 1.5 feet above the lowest point on the crest of the dam.

- c. Elevation [feet above Mean Sea Level (MSL)]. A benchmark at El 441.0 was established at the spillway crest. This elevation was estimated from a U.S.G.S. topographic map.

- (1) Top dam: 445.7 to 446.2
- (2) Test flood pool: 448.8
- (3) Design surcharge (original design):
unknown
- (4) Full flood control pool: Not Applicable
(N/A)

- (5) Recreation pool: 441.0
- (6) Spillway crest (ungated): 441.0
- (7) Upstream portal invert diversion tunnel (Worcester Diversion): 487.0 (upstream diversion spillway crest elevation: 492)
- (8) Stream bed at centerline of dam: 433.3 at top of downstream apron
- (9) Maximum tailwater: 441.7 at test flood

d. Reservoir

- (1) Length of maximum pool: 4,500 feet
- (2) Length of recreation pool: 4,500 feet
- (3) Length of flood control pool: N/A

e. Storage (acre-feet)

- (1) Test flood surcharge: 80 at El 445.7
- (2) Top of dam: 180
- (3) Flood control pool: N/A
- (4) Recreation pool: 100 (Approximate)
- (5) Spillway crest: 100

f. Reservoir Surface (acres)

- *(1) Top dam: 17
- *(2) Test flood pool: 17
- (3) Flood-control pool: N/A
- (4) Recreation pool: 17
- (5) Spillway crest: 17

*Based on the assumption that the surface area will not increase significantly with changes in reservoir elevation from 441.0 to 445.7.

g. Dam

- (1) Type: earthfill
- (2) Length: 240 feet
- (3) Height: 18 feet
- (4) Top width (earth embankment at south end of spillway): varies from 10 to 35 feet
- (5) Side slopes: upstream - vertical, downstream - filled to street grade
- (6) Zoning: Unknown
- (7) Impervious core: 4-inch timber sheeting
- (8) Cutoff: 4-inch timber sheeting in concrete
- (9) Grout curtain: Unknown

1. Spillway

- (1) Type: Narrow crest
- (2) Length of weir: 155 feet
- (3) Crest elevation: 441.0 MSL (assumed benchmark)
- (4) Gates: None
- (5) Upstream channel: stone masonry side-walls along pond
- (6) Downstream channel: 12-foot-wide concrete apron at downstream toe. Leads to 165-foot-wide channel with vertical masonry walls 12.5 feet high.
- (7) General: Downstream railroad bridge 25 feet from dam - then culvert under Greenwood Street, to stream channel with mortared masonry sidewalls. Channel takes 90 degree bend to southeast about 500 feet from dam.

- J. Regulating Outlets. There are two known regulating outlets at the dam. One is located at the south abutment of the spillway. It is a 6 foot long, mortared stone sluiceway which is controlled by a 6- by 5-foot slide gate. This outlet is missing the wooden portion of the gate stem and is inoperable. The second outlet is near the abutment of the dam, and closer to Greenwood Street. It is a concrete sluiceway controlled by a 4-foot by 3-foot slide gate. The gate, although reportedly still operable, has not been used in over 5 years. There is also evidence of two other abandoned outlets within the pond. There is no information available on these outlets.

SECTION 2

ENGINEERING DATA

- 2.1 General. The only plans, specifications, or computations available from the Owner or State or County offices relative to the design, construction or repair of this dam is a "Plan of Dam Across the Blackstone River" filed in July 28, 1891. This plan shows details of the spillway weir, the concrete apron at the downstream toe, and two cutoff walls. A copy of this plan is included in Figure B-3 in Appendix B.

Supplementary information for the hydraulic-hydrologic evaluation for the dam was provided by U. S. Army Corps of Engineers "Design Memorandum No. 1" dated August 1975 for the Worcester Diversion. Three plans for this tunnel and the control dam were provided by the Corps, but were not included in this report. The only other data available for this evaluation were visual observations during inspection, review of previous inspection reports, and conversations with the Owner and with personnel from the State, County, and City agencies.

We acknowledge the assistance and cooperation of personnel of the Massachusetts Department of Public Works: Messrs. Willis Regan and Raymond Rochford, and of the Massachusetts Department of Environmental Quality Engineering, Division of Waterways: Messrs. John J. Hannon and Joseph Iagallo.

Also, we acknowledge the cooperation and assistance of personnel from the Worcester County Engineer's Office: Messrs. John O'Toole, Joseph Brasauskas, and Mr. Wallace Lindquist - recently retired from county service.

In addition, we thank Mr. Thomas M. Kennedy of the Riley Stoker Corporation, Owner of the dam, who gave permission to inspect the dam and provided access to the outlet structures.

- 2.2 Construction Records. The only construction record is the 1891 Plan referred to in section 2.1 and included in Appendix B. There are no as-built drawings for the dam, spillway and outlet structures.
- 2.3 Operating Records. No operating records are available, and there is no daily record kept of the elevation of the pool or rainfall at the dam site.
- 2.4 Evaluation.
- a. Availability. Due to the age of this dam, there is limited engineering data available.
 - b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history, and sound engineering judgment.
 - c. Validity. The limited engineering data available is considered valid.

SECTION 3

VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I inspection of the dam at Quinsigamond Pond was performed on August 3, 1978. A copy of the inspection checklist is included in Appendix A. Periodic inspections of this dam by others have been made since 1925. A partial listing of these inspections is in Appendix B. An inspection was made in 1973 by personnel of the Massachusetts Department of Public Works. Copies of those reports are also in Appendix B.
- b. Dam. The dam consists of a stone masonry spillway with an earthfill embankment at the southern end. The earthfill embankment includes the outlet structures. The embankment is generally in fair condition. The downstream slope has been filled in to street grade. The upstream face is a vertical cut stone wall that appears to be in fair to good condition. The crest of the embankment is covered with grass and brush, and a few stones. A large tree is growing on the south abutment, outside the chain-link fence surrounding the outlet structures. The only visible concrete structure is on the embankment in the area of the outlets.

At the north abutment of the dam, stone blocks are missing from the top of the wall. Surface runoff flows into the pond immediately upstream of the weir.
- c. Appurtenant Structures. The spillway is an arched, mortared stone structure located at the north end of the dam. Flashboards are mounted on the northern 90 feet of the crest. Upstream of the spillway there is a major accumulation of soil, vegetation, and debris. The upstream face of the spillway, which was originally constructed with stepped stone blocks, is now entirely silted in almost to the crest. The silt supports vegetation and seriously impedes the flow. This problem is particularly acute in

the area directly upstream of the section of the spillway which has flashboards. The deposition of silt and dense growth of weeds have built up the pond bed above the crest of the weir.

The flashboards have collapsed from the southern 65 feet of the crest of the spillway, and water is flowing over the weir. A broken piece of flashboard suspended by one pin remains in this section.

The stonework on the spillway is in good condition, although grass is growing between the blocks on the face of the weir, and on the sidewalls.

Two outlets which are located at the south abutment of the dam are surrounded by a locked chain-link fence. The channel nearest the spillway is in poor condition. The approach channel and intake are submerged, and the stone masonry sidewalls and concrete headwall of the outlet structure appear to be in fair condition. The wooden parts of the gate stem are missing, however, making the gate inoperable. There is a thick growth of shrubbery on top of the outlet structure. The outlet channel which connects with the spillway channel appears to be clear of debris.

The second outlet is closer to Greenwood Street, and was used to provide water to the former steel mill. The concrete of the sluiceway is in fair condition, with minor spalling and erosion evident, but no staining. The Owner reports that the gate is still operable. The downstream outlet channel is not visible. There is also evidence of two other abandoned outlets within the pond.

- d. Reservoir Area. Quinsigamond Pond is bounded on the west by Middle River Park, and beyond that by Holy Cross College on College Hill. The rest of the pond area is surrounded by highly urbanized sections of Worcester, including a number of factories downstream. At the upstream end of the pond, the Middle River flows under I-290 before discharging into Quinsigamond Pond.

- e. Downstream Channel. The discharge from the spillway flows in the stream channel under the railroad bridge and Greenwood Street, and into the Blackstone River. The channel has vertical mortared stone sidewalls for at least 500 feet below the dam, where it makes a 90 degree bend to the southeast.

3.2 Evaluation. The above findings indicate that there are areas of concern at the dam which require attention. It is evident that the dam is not adequately maintained and that deterioration will continue unless action is taken. Recommended measures to improve these conditions are stated in Section 7.

SECTION 4

OPERATING PROCEDURES

- 4.1 Procedures. There are no operating procedures at Quinsigamond Pond Dam.
- 4.2 Maintenance of the Dam. The dam is not adequately maintained. Silt, debris and vegetation have been allowed to accumulate in the pond and approach to the spillway. This condition has been of major concern as noted on previous inspection reports since 1938. Also, the growth of trees and brush on the embankment and between the stone blocks of the upstream walls has not been controlled.
- 4.3 Maintenance of Operating Facilities. One of the outlets at the south end of the spillway is inoperable. The slide gates are closed and cannot be opened with the existing mechanism. It is reported that the other outlet is operable.
- 4.4 Description of Any Warning Systems in Effect. There are no warning systems in effect at this dam.
- 4.5 Evaluation. There are no operational, maintenance, or warning systems in effect at Quinsigamond Pond Dam. This is extremely undesirable considering the fact that it is in the "high" hazard category. A program of operation and maintenance for this dam should be implemented as recommended in Section 7.

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design Data. The Probable Maximum Flood (PMF) rate was determined to be 850 cfs per square mile. This rate was determined based upon the U. S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Flow Rates, dated December 1977, modified to show the calculated peak flow rate for Leesville Pond (MA 00141) and extrapolated to different tributary areas.

The total drainage area to Quinsigamond Pond Dam was calculated to be approximately 63 square miles, and includes the tributary drainage areas for Leesville Pond (32.1) Coes Reservoir (10.9), Curtis Ponds (1.2), and the 18.7 square miles of area contributing directly to Quinsigamond and comprising most of urban Worcester. The Mill Brook storm drain, which discharges just downstream of Quinsigamond Pond, collects drainage from 11.3 square miles of the City of Worcester. Subtracting this diverted flow from 63 square miles results in a directly tributary drainage area for Quinsigamond Pond of 51.7 square miles.

Applying one-half the PMF rate to the 51.7 square miles and using an appropriate reduction factor for areas exceeding 10 square miles results in a calculated inflow test flood of 20,475 cfs. The Worcester Diversion just upstream of Leesville Pond can divert 6,000 cfs directly to the Blackstone River downstream of Quinsigamond Dam. Therefore, the final adjusted inflow test flood is anticipated to be 14,475 cfs.

An alternative method for verification of the calculated inflow test flood was to use the peak outflows of both Coes and Leesville Reservoirs (calculated in previous Phase I Inspection Reports MA 00120 and 00141) plus the total flow from the remaining 8.7 square miles of drainage to Quinsigamond. This method gives an inflow test flood of 19,800 cfs.

The average of the two flow rates was calculated to be 17,140 cfs (332 cfs per square mile) and was used as the inflow test flood for this analysis. By adjusting the inflow test flood for surcharge storage, the maximum discharge rate was established as 17,075 cfs, with the water surface at El 448.8. Flow over the crest of the embankment is predicted to be 1,020 cfs while flow over the main spillway would be 16,055 cfs. The maximum head on the dam would be 3.1 feet, with a discharge of 14 cfs per foot of width. The depth of water over the dam at critical flow would be 0.76 feet with a velocity of 5.0 feet per second.

Hydraulic analyses indicate that the spillway can discharge flows of 6,600 cfs with a water surface at El 445.7 which is a low point of the dam.

- b. Experience Data. Hydraulic records are not available. A review of past records and discussions with County personnel indicated that the dam was not overtopped during the 1938 or the 1955 floods; however, the 1936 flood reached El 447 as indicated on the list of partial inspections (see page B-4). This is 1.5 feet above the low point on the crest of the dam but below the top of the railroad rails just downstream of the dam.
- c. Visual Observations. Discharge from Quinsigamond Pond is over an arched, masonry spillway about 155 feet long with an 8 foot vertical downstream face. Water flows beneath a railroad trestle bridge about 20 feet downstream and then through a more constricted opening under Greenwood Street. Two unknown outlet structures are located at the southerly end of the dam. There is also evidence of two other abandoned outlets within the pond.

Eighteen-inch-high flashboards are present along the spillway although in one section the flashboard has partially fallen off. Immediately upstream of the spillway, at the north abutment, the approach is filled with silt and cluttered with debris.

- d. Overtopping Potential. Overtopping of the dam is expected under the inflow test flood of 17,140 cfs. Failure of the dam during peak test flood outflow would cause only a small increase in discharge. This is due to the fact that the spillway would already be discharging at a high rate under the test flood and would be submerged by the discharge tailwater.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual Observations. The evaluation of the structural stability of Quinsigamond Pond Dam is based on the visual inspection of August 3, 1978. Based on the visual observations as detailed in Section 3, Visual Inspection, Quinsigamond Pond Dam does not appear to be unstable. However, in the event the soil is removed upstream of the spillway, an unstable condition could result. An analysis to determine the limits of dredging should be performed so that the stability and impermeability of the dam is unimpaired.
- b. Design and Construction Data. The 1891 drawing showing the details of the spillway section is the only available information relative to the design and construction of the dam. Information on the type, shear strength, and permeability of the soil and/or rock materials of the dam embankment does not appear to exist.

The cutoff for the spillway is shown in Figure B-3 as 4-inch sheeting in concrete. Protection of the downstream toe of the spillway is provided by a concrete slab and wood plank-ing.

- c. Operating Records. There is no evidence that instrumentation of any type was ever installed in Quinsigamond Pond Dam. The performance of this dam under prior loading can only be inferred by previous records and physical evidence at the site.
- d. Post-Construction Changes. There are no as-built drawings for the dam. As discussed in Section 1.2.h, previous inspection reports indicate that in 1936 a cutoff of wood sheeting and 36 feet of earth embankment were constructed. In 1945, a "new concrete headwork" had been constructed for the outlet gate near Greenwood Street.

- e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with Phase I "Recommended Guidelines" does not warrant seismic analyses.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition. Quinsigamond Pond Dam was neither designed nor constructed according to the current approved state-of-the-art procedures. Based upon the visual inspection at the site, the lack of engineering data, and limited evidence of operational or maintenance procedures; there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the dam is considered to be in fair condition. One of the most serious signs of distress observed at the site was extensive deposition of silt upstream of the spillway. On the northern half of the weir, where the flashboards are in place, soil, weeds, and brush have accumulated above the crest of the spillway. This condition restricts flow over about 90 feet of the spillway. In addition, silt which has been deposited farther upstream has significantly reduced the storage capacity of the pond. The flashboards on the southern portion of the weir have been washed away, and normal flow is over that section of the spillway. That area is also silted up on the upstream face almost to the crest.

Other signs of distress are: the growth of grass between stone blocks on the face of the spillway, the missing gate stem on the outlet at the south end of the spillway, trees growing on the earth embankment near the outlet structures, and stonework missing from the north abutment of the spillway.

Hydraulic analyses indicate that the existing spillway can discharge a flow of 6,600 cfs at El 445.7 which is the low point on the crest of the dam. An inflow test flood of 17,140 cfs will overtop the dam by a maximum of 3.1 feet.

Previous records indicate the dam may have been overtopped by 1.5 feet during the 1936 storm. However, due to the present regulating effects of the upstream flood control structure which was installed in 1959, it is unlikely that this is a serious hazard.

- b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.
- c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within one year after receipt of this Phase I Inspection Report.
- d. Need for Additional Information. Additional investigations to further assess the adequacy of this dam are not required at the present time except in regard to the limits of dredging to remove accumulated soil. Remedial measures for repairing and maintaining the dam are stated below in Section 7.3 Remedial Measures.

- 7.2 Recommendations. As a result of the visual inspection and a review of available data, further investigations to assess the adequacy of the dam are not considered necessary at this time except in regard to proposed dredging. Prior to any dredging it is recommended that the Owner employ a qualified consultant to determine the limits of dredging so that the stability and impermeability of the dam is unimpaired. Also, future changes within the watershed or to the dam and/or spillway may necessitate further investigations.

The recommendations on repair and maintenance procedures are stated below in Section 7.3.

7.3 Remedial Measures

- a. Alternatives. An alternative to recommendations above and the maintenance procedures

itemized below would be to drain the pond and breach or remove the dam. However, prior to breaching the dam all accumulated soil within the pond should be removed and disposed of off-site.

- b. Operating and Maintenance Procedures. The dam and appurtenant structures are not adequately maintained. It is recommended that the Owner accomplish the following:
- (1) remove the flashboards from the northern 90 feet of the weir of the spillway
 - (2) dredge soil and vegetation from the area upstream of the spillway. The limits of dredging should be based on an analysis as recommended above
 - (3) repair the gate stem on the outlet works next to the south abutment of the spillway and determine that the gate operates properly
 - (4) clear trees and brush from the earth embankment at the south end of the dam near the outlet structures
 - (5) repair stone blocks missing from the top of the wall just upstream of the north abutment of the dam
 - (6) institute a definite plan for surveillance and a warning system during periods of unusually heavy rains and/or runoff; this should be coordinated with the operators of upstream reservoirs
 - (7) implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances supplemented by additional inspections during and after severe storms. All repairs and maintenance should be undertaken in accordance with all applicable State regulations.

- (8) periodic technical inspections of this dam should be continued on a bi-annual frequency.

APPENDIX A
PERIODIC INSPECTION CHECK LIST

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Quinsigamond Pond

DATE August 3, 1978

TIME 8:00 AM - 1:00 PM

WEATHER Sunny - 75° F

W.S. ELEV. 441.1* U.S. 434.5 D.N.S.

*assumed benchmark El 441 at spillway crest from USGS topo quad

PARTY:

- | | |
|-------------------------|-----------|
| 1. <u>Lyle Branagan</u> | 6. _____ |
| 2. <u>David Cole</u> | 7. _____ |
| 3. <u>Lou Taverna</u> | 8. _____ |
| 4. <u>Ed Greco</u> | 9. _____ |
| 5. _____ | 10. _____ |

PROJECT FEATURE

INSPECTED BY

REMARKS

- | | |
|----------------------------|-----------------------------------|
| 1. <u>dam and spillway</u> | <u>Lyle Branagan and Ed Greco</u> |
| 2. <u>outlets</u> | <u>Lyle Branagan</u> |
| 3. _____ | _____ |
| 4. _____ | _____ |
| 5. _____ | _____ |
| 6. _____ | _____ |
| 7. _____ | _____ |
| 8. _____ | _____ |
| 9. _____ | _____ |
| 10. _____ | _____ |

PERIODIC INSPECTION CHECK LIST

PROJECT Quinsigamond Pond Dam

DATE August 3, 1978

PROJECT FEATURE dam embankment

NAME Lyle Branagan

DISCIPLINE geotechnical

NAME Ed Greco

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	<i>varies from 445.5 to 446.2</i>
Current Pool Elevation	<i>441.1</i>
Maximum Impoundment to Date	<i>unknown</i>
Surface Cracks	<i>none visible</i>
Pavement Condition	<i>not applicable</i>
Movement or Settlement of Crest	<i>minor irregularities</i>
Lateral Movement	<i>none visible</i>
Vertical Alignment	<i>relatively flat</i>
Horizontal Alignment	<i>relatively straight</i>
Condition at Abutment and at Concrete Structures	<i>fair to good</i>
Indications of Movement of Structural Items on Slopes	<i>none visible</i>
Trespassing on Slopes	<i>upstream face heavily silted</i>
Sloughing or Erosion of Slopes or Abutments	<i>none visible</i>
Rock Slope Protection - Riprap Failures	<i>none visible</i>
Unusual Movement or Cracking at or near Toes	<i>none visible</i>
Unusual Embankment or Downstream Seepage	<i>minor seepage</i>
Piping or Boils	<i>none visible</i>
Foundation Drainage Features	<i>none visible</i>
Toe Drains	<i>none visible</i>
Instrumentation System	<i>none visible</i>

PERIODIC INSPECTION CHECK LIST

PROJECT Quinsigamond Pond Dam DATE August 3, 1978
 PROJECT FEATURE Spillway NAME Lyle Branagan
 DISCIPLINE geotechnical NAME Ed Greco

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	same as river channel
General Condition	severe siltation
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	small trees + brush
Floor of Approach Channel	natural stream bed
b. Weir and Training Walls	fair to good - stone masonry
General Condition of Concrete	not applicable
Rust or Staining	not applicable
Spalling	not applicable
Any Visible Reinforcing	not applicable
Any Seepage or Efflorescence	minor seepage
Drain Holes	not applicable
c. Discharge Channel	under RR bridge + Greenwood Street
General Condition	fair to good with some debris
Loose Rock Overhanging Channel	no
Trees Overhanging Channel	small trees
Floor of Channel	natural with concrete + wood scour protection
Other Obstructions	two adjacent bridges

PERIODIC INSPECTION CHECK LIST

PROJECT Quinsigamond Pond Dam
 PROJECT FEATURE outlet structures
 DISCIPLINE geotechnical

DATE August 3, 1978
 NAME Hyle Branagan
 NAME Ed Greco

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE</u>	
a. Approach Channel	<i>Same as river channel</i>
Slope Conditions	<i>vertical masonry wall</i>
Bottom Conditions	<i>natural channel</i>
Rock Slides or Falls	<i>none</i>
Log Boom	<i>not applicable</i>
Debris	<i>minor</i>
Condition of Concrete Lining	<i>not applicable</i>
Drains or Weep Holes	<i>not applicable</i>
b. Intake Structure	<i>two inlets</i>
Condition of Concrete	<i>fair to good</i>
Stop Logs and Slots	<i>no logs- slots in concrete</i>

PERIODIC INSPECTION CHECK LIST

PROJECT Quinsigamond Pond DamDATE August 3, 1978PROJECT FEATURE outlet structuresNAME Lyle BranaganDISCIPLINE geotechnicalNAME Ed Greco

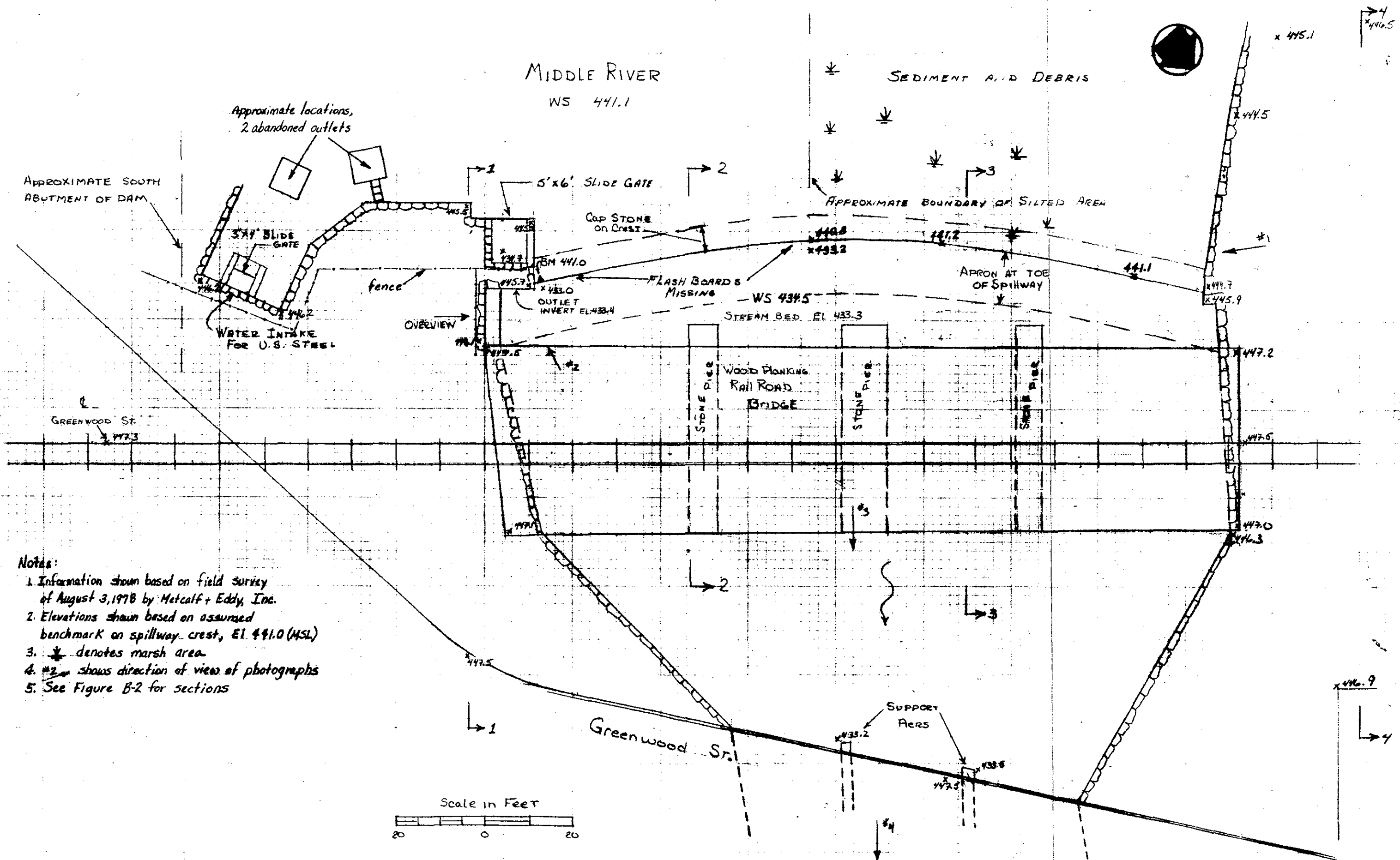
AREA EVALUATED	CONDITION
<u>OUTLET WORKS - TRANSITION AND CONDUIT</u>	
General Condition of Concrete	<i>fair to good</i>
Rust or Staining on Concrete	<i>none</i>
Spalling	<i>minor</i>
Erosion or Cavitation	<i>minor</i>
Cracking	<i>none visible</i>
Alignment of Monoliths	<i>not applicable</i>
Alignment of Joints	<i>fair to good</i>
Numbering of Monoliths	<i>not applicable</i>

discharge channels:

*outlet next to spillway - same channel as spillway**outlet next to Greenwood St - discharge off site*

APPENDIX B

	<u>Page</u>
Figure B-1, Plan of Dam	B-1
Figure B-2, Sections	B-2
Figure B-3, Plan of Dam filed July 1891	in pocket
Previous Inspections (partial listing)	B-4
Previous Inspection Report by Massachusetts Department of Public Works, February 1973	B-6



METCALF & EDDY, INC.

FIGURE B-1 PLAN OF DAM

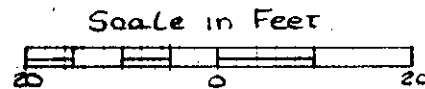
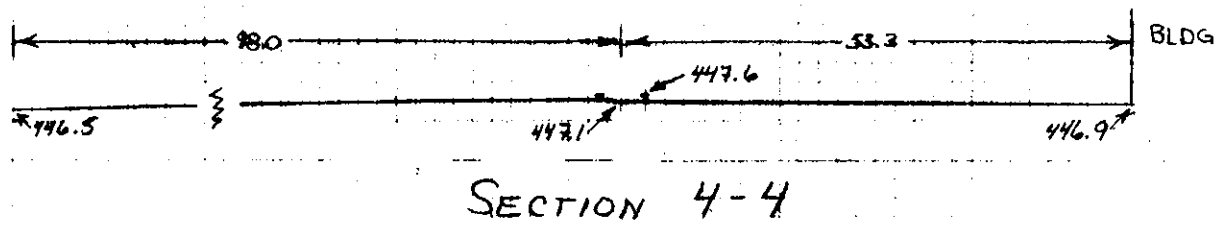
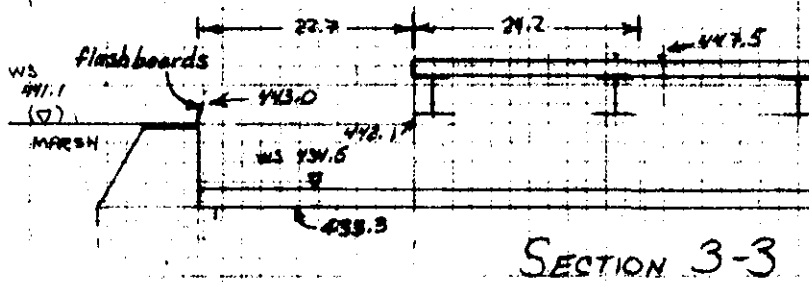
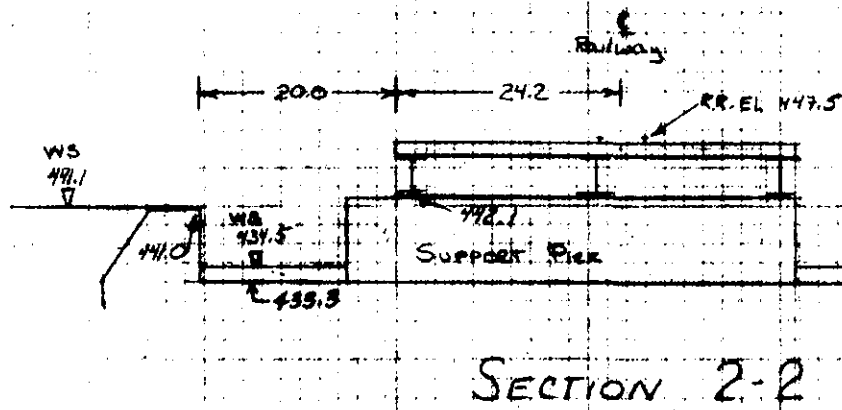
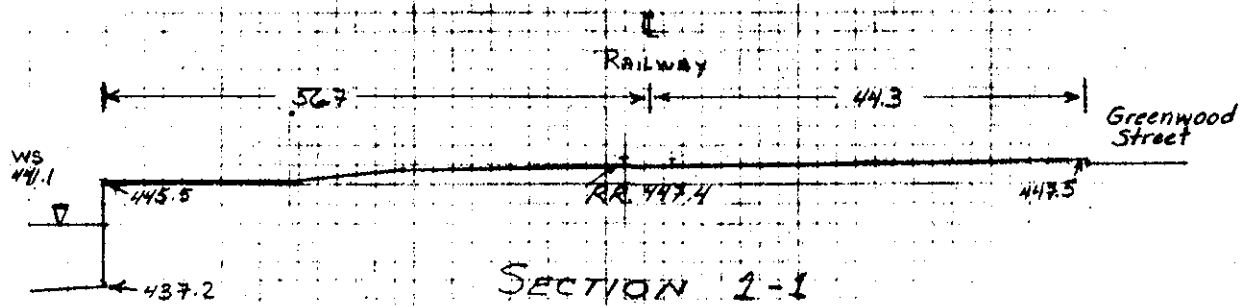
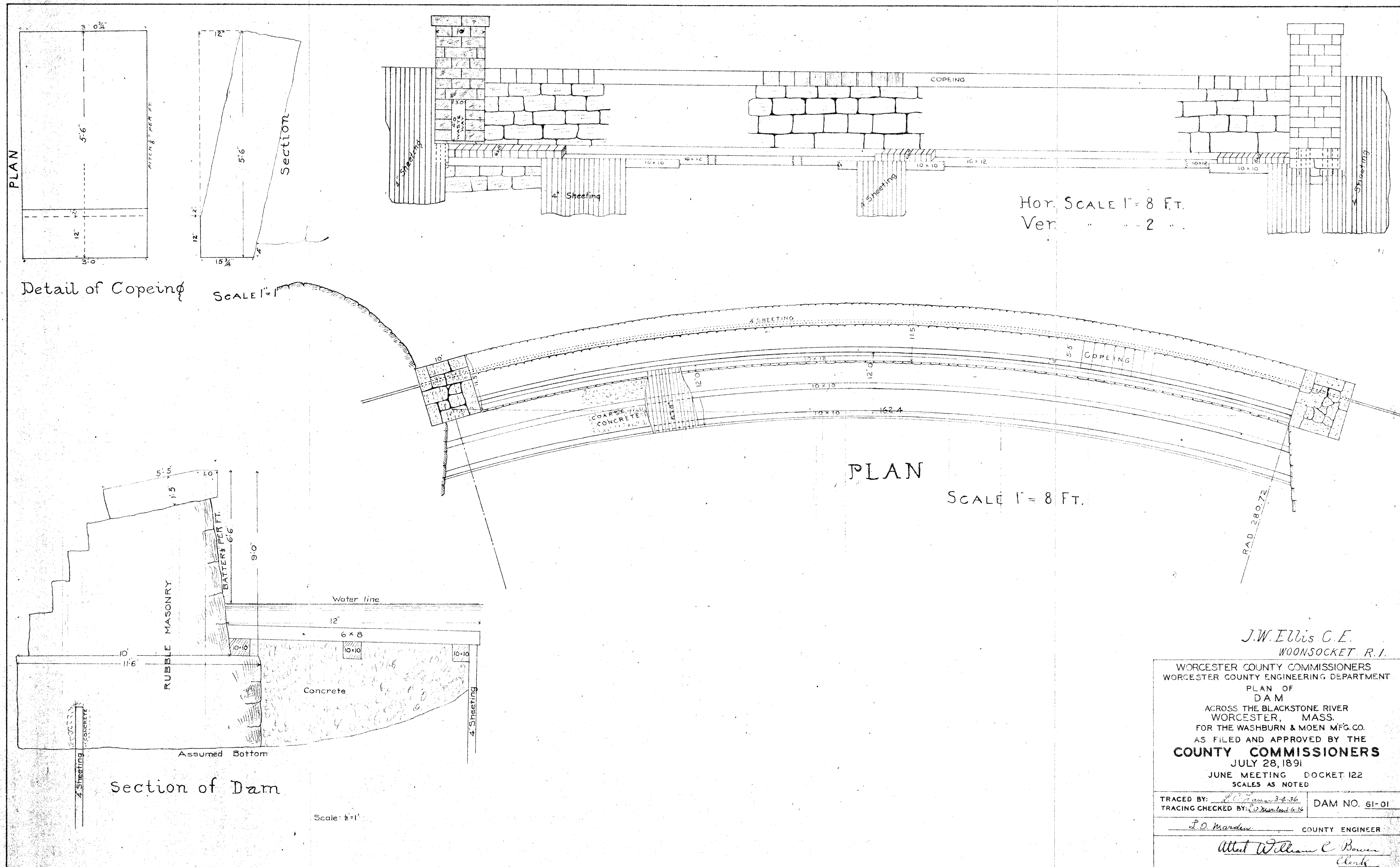


FIGURE B-2 SECTIONS



J.W. Ellis C.E.
WOONSOCKET, R.I.

WORCESTER COUNTY COMMISSIONERS
WORCESTER COUNTY ENGINEERING DEPARTMENT
PLAN OF
DAM
ACROSS THE BLACKSTONE RIVER
WORCESTER, MASS.
FOR THE WASHBURN & MOEN MFG.CO.
AS FILED AND APPROVED BY THE
COUNTY COMMISSIONERS
JULY 28, 1891
JUNE MEETING DOCKET 122
SCALES AS NOTED

TRACED BY: L. C. Tamm 3-4-36
TRACING CHECKED BY: P. O. Murden 3-6-36

L. O. Marden COUNTY ENGINEER

Attest William C Bower
Clerk

TOWN OR CITY	Worcester	DECREE NO.	122	PLAN NO.	122	DAM NO.	81-01
LOCATION	South Works- Millbury St. Quinsigamond Pond. 348						
DESCRIPTION OF DAM				DESCRIPTION OF RESERVOIR & WATERSHED			
Type	Earth, Stone faced spillways.			Name of Main Stream	Blackstone River.		
Length				" " any other Streams			
Height	9.0			Length of Watershed			
Thickness top	5.5			Width " "			
" bottom	10.0			Is Watershed Cultivated			
Downstream Slope	12:1			Percent in Forests			
Upstream "				Steepness of Slope			
Length of Spillway	El. Top of Weir 437.8 125' 152'			Kind of Soil			
Size of Gates	3x3			No. of Acres in Watershed	58.85 17		
Location of Gates	So. End Spillway			" " " " Reservoir			
Flashboards used	None.			Length of Reservoir			
Width Flashboards or Gates				Width " "			
Dam designed by	J. W. Ellis.			Max Flow Cu. Ft. per Sec.			
" constructed by				Head or Flashboards-Low Water			
Year constructed	1906			" " " " High "			
GENERAL REMARKS				GENERAL REMARKS			
Owned by Am. Steel & Wire Co. Vol. 28 - P. 30. - July 28, 1891, June Mtg. Inspected Oct. 5, 1925. L. A. M. O.K. Plan - "Dams" C.C. Office Inspected: Oct. 29, 1928 / L. A. M. O.K. " : Sept. 29, 1932 / " " : Mar. 1, 1933 / " " : Nov. 18, 1938 / L. H. Spofford " : Dec. 10, 1940. "				New Plans & Specs approved 9-15-36 by C. C. See plan in Commissioners Office (Docket #122. Meeting June, 1891. Filed July 28, 1891 Traced by: L. C. Farrar, March 4, 1936. Checked by: L. A. Marden " 6, " Attested by: William C. Bowen C. of C. J. W. Ellis, C. E.-Woonsocket, R.I. 1936 Flood 447.0			

B-4

PREVIOUS INSPECTIONS (PARTIAL LISTING)

COPY OF INSPECTION CARD ON FILE AT THE MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS, DISTRICT OFFICE, WORCESTER.

Inspected: Dec. 11, 1945 - W.O. Lindquist

61-01

June 16, 1948 - LOM

Report 2936: 36' of dike & wood sheet piling, backfilling with sandy clay
fill and riprap upstream side.

DESCRIPTION OF DAM

DISTRICT 3

Submitted by MULCAHY DONAHUE

Dam No. 3-14-348-1

Date 2-7-73

City/Town WORCESTER

Name of Dam QUINSIGAMOND POND DAM

1. Location: Topo Sheet No. 21 B

Provide 8 1/2" x 11" in clear copy of topo map with location of Dam clearly indicated.

2. Year built: _____ Year/s of subsequent repairs _____

3. Purpose of Dam: Water Supply _____ Recreational _____
Irrigation _____ Other ☒

4. Drainage Area: 58.85 sq. mi. _____ acres

5. Normal Ponding Area: 20 ± acres; Ave. depth _____

Impoundment: _____ gals.; _____ acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir

CAS STA

BUS BUILDING

i.e. summer homes, etc. _____

7. Dimensions of Dam: Length 225' ± Max. Height 11'

Slopes: Upstream Face VERTICAL

Downstream Face VERTICAL

Width across top 50' ±

8. Classification of Dam by Material:

Earth ☒ Conc. Masonry _____ Stone Masonry ☒

Timber _____ Rockfill _____ Other _____

9. A. Description of present land usage downstream of dam:

_____ % rural; 100 % urban.

B. Is there a storage area or flood plain downstream of dam which could accomodate the impoundment in the event of a complete dam failure? yes ☒ no _____

10. Risk to life and property in event of complete failure.

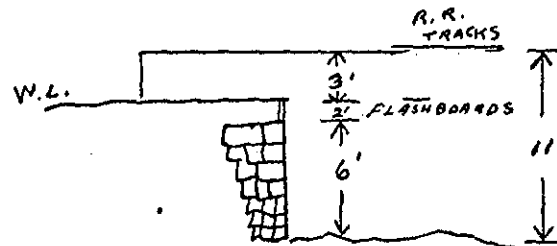
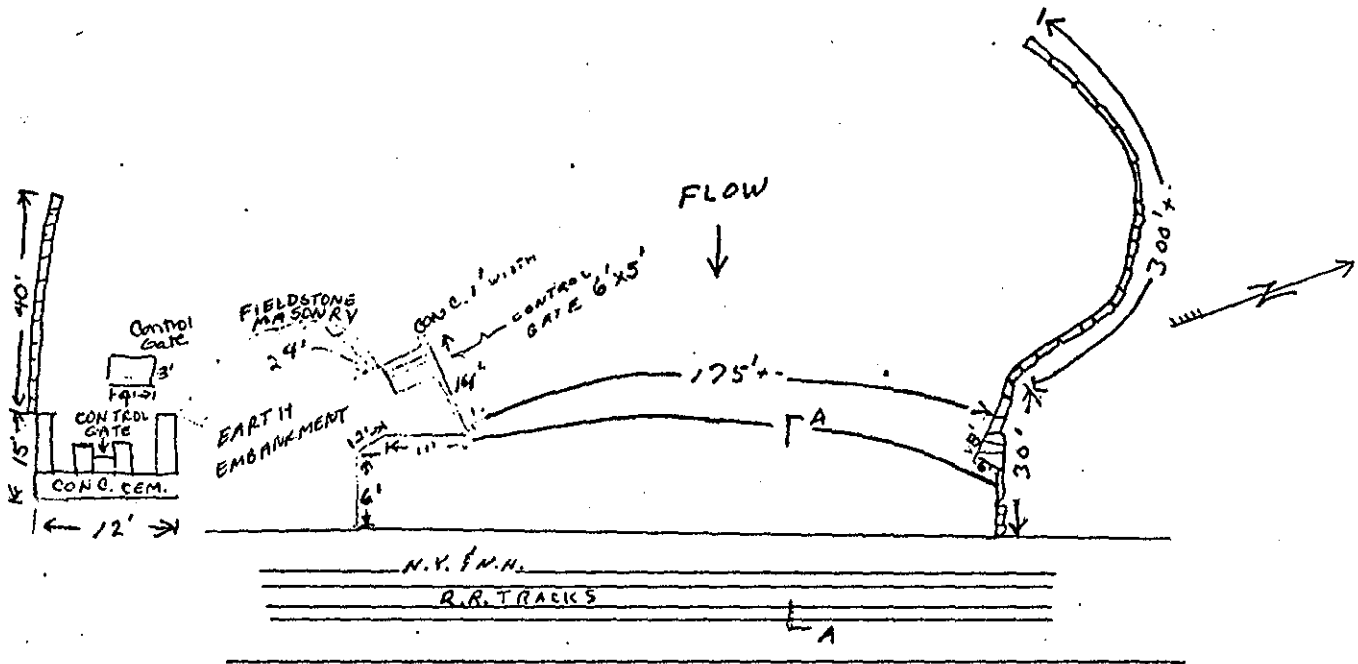
No. of people NONE.No. of homes NONE.No. of Businesses 1.No. of industries 1. Type STEELNo. of utilities NONE. Type _____Railroads N.Y. N.H. RAILROAD.Other dams NONE.

Other _____.

11. Attach Sketch of dam to this form showing section and plan on 8½" x 11" sheet.

12. How to Locate: TRAVEL SOUTH ON MILLBURY ST FROM
INTERSECTION OF MILLBURY & BALLARD STS, DAM ON
RIGHT AT RAILROAD CROSSING.

WORCESTER
QUINSIGAMOND DAM
3-14-348-1



A-A SECTION

INSPECTION REPORT - DAMS AND RESERVOIRS

1. Location: City/Town WORCESTER Dam No. 3-14-348-1

Name of Dam QUINSIGAMOND POND DAM Inspected by

Date of Inspection

2. Owner/s: per: Assessors Prev. Inspection ✓

Reg. of Deeds Pers. Contact

1. UNITED STATES STEEL CORP 767 MILLBURY ST WORCESTER
Name St. & No. City/Town State Tel. No.

2.
Name St. & No. City/Town State Tel. No.

3.
Name St. & No. City/Town State Tel. No.

3. Caretaker (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

Name: St. & No.:

City/Town: State: Tel.No.:

4. No. of Pictures taken NONE

5. Degree of Hazard: (if dam should fail completely)*

1. Minor 2. Moderate ✓

3. Severe 4. Disastrous

* This rating may change as land use changes (future development)

6. Outlet Control: Automatic Manual ✓

Operative yes; No.

Comments:

7. Upstream Face of Dam: Condition:

1. Good 2. Minor Repairs ✓

3. Major Repairs 4. Urgent Repairs

8. Comments:

8. Downstream Face of Dam:

Condition: 1. Good _____ 2. Minor Repairs ✓
3. Major Repairs _____ 4. Urgent Repairs _____

Comments:

9. Emergency Spillway: NONE

Condition: 1. Good _____ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____

Comments:

10. Water Level at time of inspection: 3 ft. above _____ below ✓
top of dam ✓ principal spillway _____
other _____

11. Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment ✓

Animal Burrows and Washouts _____

Damage to slopes or top of dam FALLEN TREE ON LEFT SIDE OF DAM

Cracked or Damaged Masonry NONE VISIBLE

Evidence of Seepage NONE

Evidence of Piping NONE

Erosion NONE

Leaks NONE

Trash and/or debris impeding flow TRASH & DEBRIS IN STREAM

Clogged or blocked spillway TRASH AND DEBRIS BLOCKING SPILLWAY

Other _____

12. Remarks & Recommendations: (Fully Explain)

THE STONE MASONRY SECTION OF THE DAM APPEARS TO BE IN GOOD CONDITION. THE PRIMARY DEFICIENCY IN THIS DAM IS THE AMOUNT OF TRASH AND DEBRIS LAYING ON TOP OF THE SPILLWAY FOR ALMOST HALF THE LENGTH OF THE SPILLWAY, WEEDS & HUMMOCKS GROWING IN APPROACH TO SPILLWAY COLLECT TRASH AND INHIBIT THE FLOW OF WATER. THERE IS AN UPROOTED TREE IN THE EXTREME LEFT SIDE OF THE DAM THAT IS LAYING IN THE POND ABOUT 25' FROM THE TOP OF THE SPILLWAY. REMOVAL OF THIS TREE IS NECESSARY TO PREVENT LOSS OF SECTION TO EARTH DAM AND POSSIBLE TO DAMAGE TO GRANITE MASONRY WALL, AND ALSO DAMAGE TO SPILLWAY AND DOWNSTREAM SECTION OF DAM IF THE TREE SHOULD BE SWEEP OVER THE DAM.

A 20' SECTION OF THE WOODEN FLASHBOARD AT THE EXTREME RIGHT SIDE OF SPILLWAY HAS BEEN TIPPED FORWARD AND A GREATER VOLUME OF WATER IS FLOWING THROUGH THIS SECTION OF THE DAM.

THE CONDITIONS LISTED SHOULD ALL BE CORRECTED TO INSURE PROPER FUNCTIONING OF THE DAM AND TO PREVENT POSSIBLE FUTURE DAMAGE TO THE STRUCTURE.

13. Overall Condition:

1. Safe ✓
2. Minor repairs needed ✓
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

Recommend removal from inspection list _____

APPENDIX C
PHOTOGRAPHS



**NO. 1 VIEW OF DAM CREST AND RAILROAD
BRIDGE FROM NORTH ABUTMENT**



**NO. 2 VIEW OF SOUTH ABUTMENT
SHOWING ABANDONED INTAKE STRUCTURE**



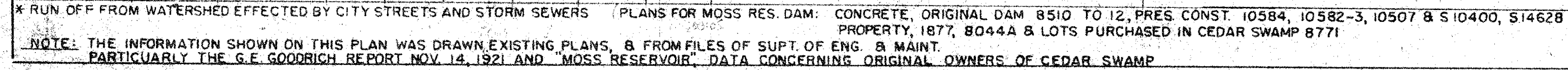
**NO. 3 VIEW OF GREENWOOD STREET BRIDGE
DOWNSTREAM FROM DAM**



**NO. 4 VIEW OF DOWNSTREAM CHANNEL FROM
GREENWOOD STREET BRIDGE**

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

	<u>Page</u>
Figure D-1, Watershed Plan	in pocket
Hydrologic and Hydraulic Computations	D-2



THIS DRAWING AND ALL INFORMATION THEREON IS THE PROPERTY OF THE AMERICAN STEEL & WIRE COMPANY AND IS CONFIDENTIAL AND MUST NOT BE MADE PUBLIC OR COPIED UNLESS AUTHORIZED BY THEM AND IS SUBJECT TO RETURN UPON DEMAND.

Y	WATER SHED OF SOUTHWORKS POND
---	----------------------------------

DAM NOS. AS NOTED IN PLAN

I Peak Inflow Test Flood & 100 Year Flood & Storage Functions

A- Inflow Test Flood

Use "Leesville" Curve, adjusted by reduction factors due to area exceeding 10 mi²

Drain Area = 51.7 mi², P.F.R. (Leesville) = 850 c.f.s./mi²

[Ref. Fig 16 - "Design of Small Dams" - U.S. B.R. for Zone I]

Leesville - 32.1 mi² - reduction factor = 88%

Quinsigamon - 51.7 mi² - " " = 82%

Due to low dam use 50% of final value.

Remove 6000 cfs diversion from final value

$$Q_A = \frac{1}{2}(850)(51.7) \frac{.92}{.88} - 6000 = 14,475 \text{ cfs} = Q_A$$

Alternate Method for Verification (prev. report values)

Peak Coes outflow - 10.9 mi² - Max Q = 8500

" Leesville " - 32.1 " " = 8700

* Remaining 8.7 sq mi - 8.7 " " = 2600

51.7

19800 c.f.s. = Q_B

* This Value = 2 x Millbrook Drain Cap. x $\frac{8.7 \text{ mi}^2}{11.3}$
 with Millbrook taken at 1675 cfs from
 M & E Report & Factor of 2 for overland
 flow under extreme storm conditions

Ave Q_A & Q_B for Inflow Test Flood = 17140 cfs. (331.5 c.s.m.)

B - 100 Year Test Flood (use prev. report values)

100 yr disch. from Coes - 3080

" " Leesville - 234

Remaining Area 11.2 x 1675 x $\frac{8.7}{11.3}$ - 1547

4860 cfs. = 100 Year St. Inflow

(94.0 c.s.m.)

C - Storage Functions

1- Inflow Test Flood.

$$Q_{Final} = Q_{in} \left(1 - \frac{S_{Final}}{9.5}\right); F_{TF} = 17140 - 1804 \cdot S$$

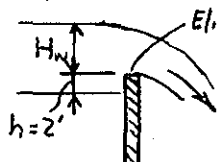
$$2- 100 \text{ yr. Flood: } F_{100} = 4860 - 1034 \cdot S$$

S = inches on watershed equal to reservoir stor. = $12 D \frac{.02}{51.7} = .00464 D$
 where D is Storage Depth on Reservoir in feet

II Discharge & Storage Function vs Pond Elev.

A- Weir

Narrow stone weir. Silt level to top of weir along most of its length. Assume high flood flows will erode 2' of silt behind weir. Length of weir 152.2' (use chord length)



$$C_w = 3.27 + 0.4 \frac{H_w}{h} \quad \text{in} \quad Q_w = C_w H_w^{3/2}$$

B- Crest (Overland) Flow

Assume no sizeable "Crest" flow until pond reaches elev. 447.5. This is due to R.R. tracks just downstream. Use 270' length for crest flow up to elevation 450 based on broad crested weir relation:

$$Q_c = 2.55 (H_c)^{3/2} \quad ; \quad H_c = H_w - 6.5; \quad Q_c = 688.5 H_c^{1.5}$$

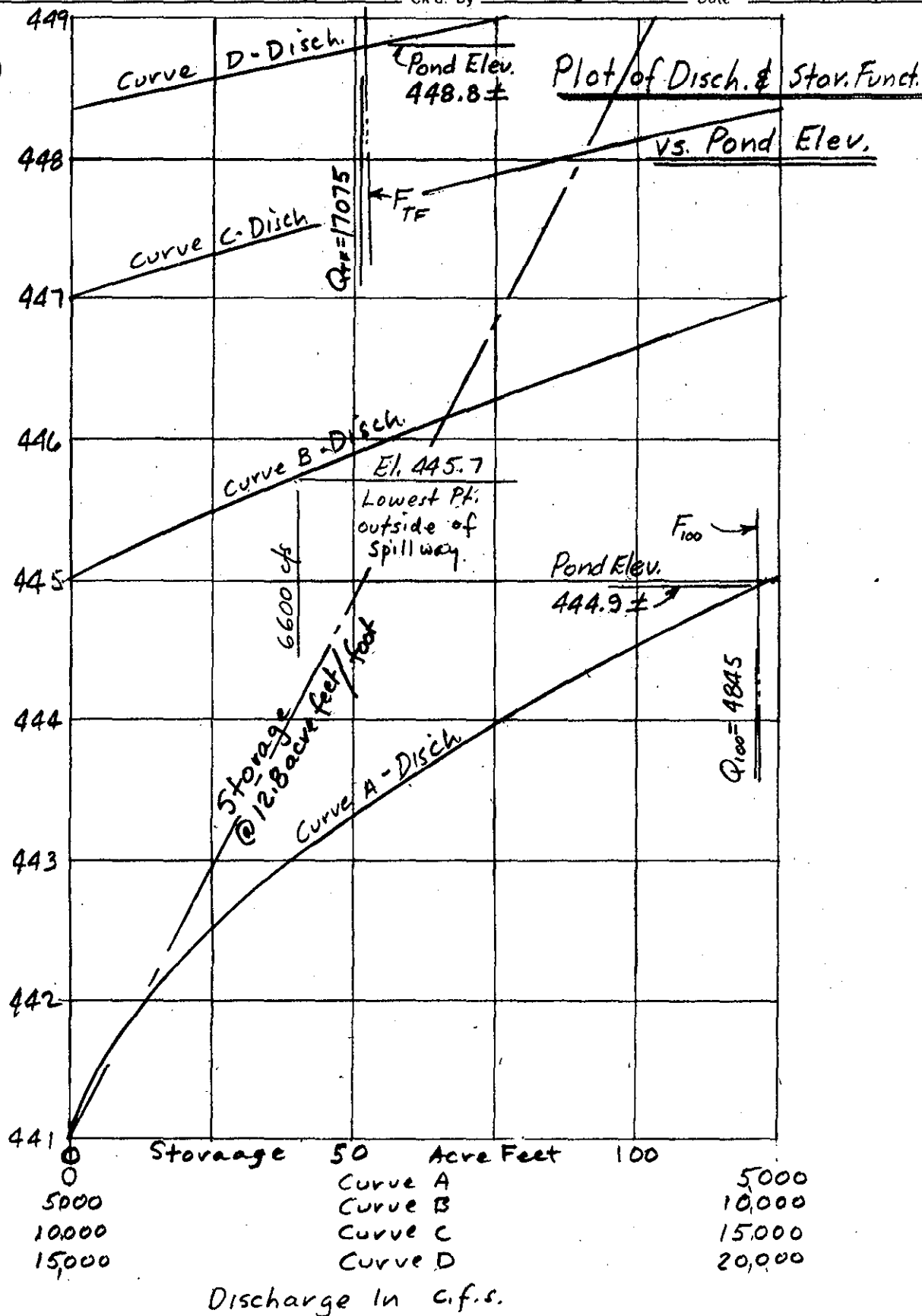
C- Totals

Pond Elev.	H _w	C _w	Q _w	Q _w L=152.2	Q _c	Q _{Tot}	S	F _{TF}	F ₁₀₀
442	1	3.47	3.47	528	—	528			
443	2	3.67	10.38	1580	—	1580			
444	3	3.87	20.11	3060	—	3060	.014		4846
445	4	4.07	32.56	4956	—	4956	.018		4840
446	5	4.27	47.74	7267	—	7267	.023		
447	6	4.47	65.70	10000	—	10000			
448	7	4.67	86.5	13165	243	13400	.032	17081	
449	8	4.87	110.2	16772	1265	18000	.037	17073	
450	9	5.07	136.9	20836	2721	23600	.042		

Project Nat. Review of Non Fed. Dams
 Subject Worcester Mass. Area
 Detail QUINSIGAMOND RES. DAM

Acct. No. 5864
 Comptd. By LEB
 Ck'd. By RW

Page 3 of 6
 Date 7/26/78
 Date 8/7/78



METCALF & EDDY, ENGINEERS

IV Failure of Dam - A-Failure With Pond@Weir Elev.

Peak Failure Flow:

Pond Elevation - 445.7

Toe Elevation - 433.0 ±

$$Y_0 = 12.7$$

Dam Length Subject to Breaching = 152' (Mainly Spillway)

$$W_0 = 40\% (152) = 61'$$

$$Q_R = 1.68 W_0 (Y_0)^{1.5} = 1.68 (61') (12.7)^{1.5} = 4640 \text{ c.f.s.}$$

Spillway Disch. 6600 cfs; T.W. Depth 5.5'; Area = 1004 ft²; $Q_1 = 11240 \text{ cfs}$

Storage Volume Released:

Storage Above Spillway: From Graph = 83

Storage Below Spillway: $2 (.02) 640 = 26$

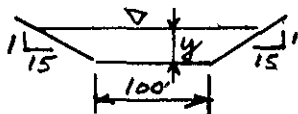
$S = \text{Total Storage} = 109 \text{ acre ft.}$

Channel Hydraulics:

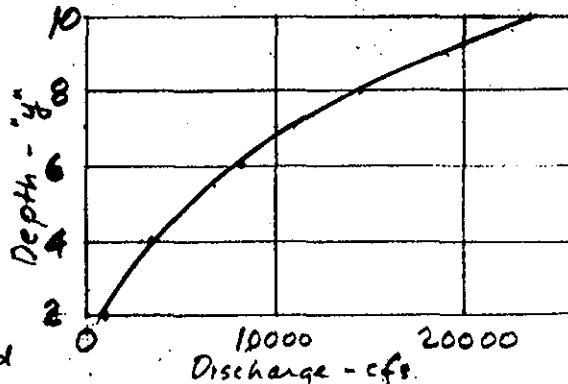
$$S = \frac{10}{1800} = .00555; n = .04$$

$$A = y(100 + 15y); P \approx B = 100 + 30y$$

$$V = 2.78 R^{4/3}$$



y	A	P	R ^{2/3}	V	Q
2	260	160	1.382	3.84	999
4	640	220	2.038	5.67	3626
6	1140	280	2.550	7.09	8081
8	1760	340	2.990	8.32	14641
10	2500	400	3.393	9.43	23582
12	3360	460	4.433	12.32	41407



1st Reach: 400' to bldg. @ channel bend

$$Q_1 = 11240; y_1 = 7.1'; A_1 = 1460; Vol_1 = 4.2 \text{ ac ft.}$$

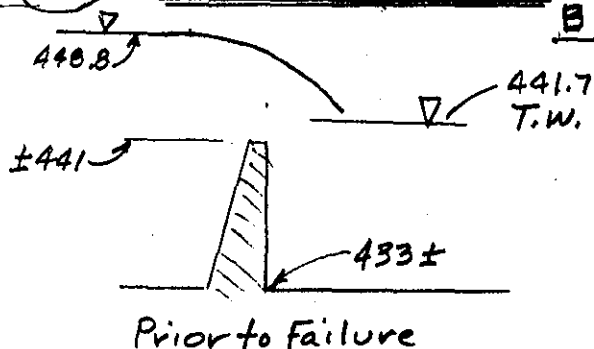
$$Q_2 = 11240 \left(1 - \frac{4.2}{109}\right) = 10800 \text{ cfs.}; \text{Wave Ht.} \approx 7.0'$$

$$\text{Say } Q_{\text{Final}} = 11000 \text{ cfs.}, y \approx 7.0', \Delta Tw = 1.5'$$

Time to Drain:

$$\frac{43560 (109)}{3600 (\frac{1}{2}) (4640)} = 0.57 \text{ Hours} = 34 \text{ Min.}$$

IV Failure of Dam (Cont.)



B - Failure Under Peak Flow:

The only major section of this dam likely to fail under high flows is the 152' of weir section.

Prior to failure at peak flows this section disch. at 105.2 cfs/ft.

The failure of a section of the weir would result in a discharge of:

$$Y_0 = 448.8 - 441.7 = 7.1'; Q_p = 1.68(7.1)^{1.5} = 31.8 \text{ cfs/ft}$$

Total Failure Flow:

$$Q_T = 17075 + 61(31.8) = 19000 \text{ cfs}$$

Tailwater would rise from 8.7' depth to 9.0' depth due to dam failure during peak Test Flood outflow

(V) Summary of Resulting Flows

A. Inflow Test Flood

Peak Outflow 17075 c.f.s. @ Pond El. 448.8 (330 c.s.m.)

Peak Spillway Flow = 16055 c.f.s.

Peak Overland (Crest) Flow = 1020 c.f.s.

Unit Overland Flow = $\frac{1020}{270} = 3.78 \text{ c.f.s./ft.}$

Critical Depth = 0.76 ; Critical Vel. = 5.0 fps.

Tailwater El. (approx.) = 8.0' + 433 = 441.0

B. 100 Year Flood

Peak Outflow 4845 c.f.s. @ Pond El. 444.9 (94 c.s.m.)

No Appreciable Overland (Crest) Flow

Tailwater Elev. (approx.) = 4.5' + 433 = 437.5

(VI) Outlet Capacity

Length is short - treat as orifice: 4.75' x 3' wide

Inu. El. 433.4 ; Pond El. 441.0 , Head = 7.6' , $H/D = \frac{7.6}{4.75} = 1.6$

$Q = 3 \times 50 = 150 \text{ c.f.s. (2.9 c.s.m.) [with Pond @ Dam Crest El.]}$

APPENDIX E
INVENTORY FORMS